Electricity Meter With Multiple Gain Signals To An A/D Converter

PRIORITY CLAIM

[0001]   This application claims priority of US Provisional Patent, Serial No. 60/484,431, filed July 2, 2003, entitled "Electricity Meter With Multiple Gain Signals To An A/D Converter", the teaching of which are incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

[0002]   This invention relates to electricity or power meters, and more particularly to low cost electricity meter with multiple gain signals sent to the A/D converter.

BACKGROUND OF THE INVENTION

[0003]   In a typical electricity meter measurement environment, the amount of electric current or power consumed can vary by as much as a hundred times as different appliances are switched on an off. One type of digital electricity meter has a high resolution ADC with enough resolution to measure the current signal under the full range of variation and yet keep within the required accuracy specifications. However, since high resolution ADCs are expensive, "auto-ranging" techniques were developed that use an external amplifier together with a lower resolution ADC to achieve the same accuracy requirement at lower cost.

[0004]   In auto-ranging, as the amount of electric current decreases, the current signal will get weaker. In response, the auto-ranging circuit will increase the gain of an amplifier to boost the current signal before it goes into the A/D converter. This keeps the amplifier's output range dynamically matched with the A/D converter's input range so that even under weak current conditions the A/D output will be in the proper range. The system tracks the gain used by the amplifier and scales the results accordingly. For example, a 60A current gives an A/D output of 0-200 with an 8-bit ADC. When the current drops to 15A (one quarter of its original value), in an auto-ranging system, the gain of the amplifier is increased by 4 times so that the signal looks like a 60A signal to the A/D and it still output between 0-200 at 8 bit resolution. So effectively, the dynamic range is (0-200)x4 which is the same as that of a 10 bit ADC.

[0005]   The ideal situation is to perform auto-ranging on every sample, however, system limitations, like the gain switching speed of the amplifier and the stability of the circuit etc., limits the auto-ranging to blocks of samples. Typically, this block consists of thousands of samples which take about 0.5 seconds to 1 second to complete.

[0006]   Figure 1 illustrates a problem with prior art auto-ranging systems. Because the prior art circuit processed the data in blocks, if the amount of current consumed suddenly increases from a very small amount to a very large amount 10 during a block, then it is quite possible that the gain setting of the amplifier is so large that the amplifier goes into saturation 12 (limited output). When the amplifier goes into saturation, the A/D reading will be inaccurate for the saturation portion of the block. The

reading will be incorrect until the system re-adjusts the gain for a subsequent block **14** to prevent the saturation **16**. In certain types of appliances like an electric water heater, this sudden increased current consumption can happen in bursts as the thermostat switches on and off continuously and therefore the auto-ranging system can yield very inaccurate results.

Figure 1a shows the 1st block suffers from error before the gain is adjusted. Figure 1b shows the second block has the correct gain setting.

SUMMARY OF THE INVENTION

[0006]   The present invention overcomes problems associated with the described prior art auto-ranging circuit. In a preferred embodiment, multiple current signal paths are amplified by a different amount of gain, and then applied to the ADC. The ADC then converts each of the amplified signals at different gains in a continuous process. The system analyzes the different sets of samples to determine which is the most accurate to use.

[0007]   Advantages of an embodiment of the present invention include improved accuracy of an electricity meter using a lower cost A/D converter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]   FIGURE 1 illustrates an electricity meter system according to the prior art.

FIGURE 2 illustrates an electricity meter system according to an embodiment of the present invention.

FIGURE 3 illustrates an electricity meter system according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0009]   Figure 2 illustrates the solution according to an embodiment of the present invention. In the illustrated embodiment, multiple current paths are amplified by a different amount of gain, and then applied to the ADC. The ADC then converts each of the amplified signals at different gains in a continuous process. The system analyzes the different sets of samples to determine which is the most accurate to use.

[0010]   In Figure 2, and input signal **100** is applied to three amplifiers **102** each having a different gain to produce output signals **104**. The output of the amplifiers is shown graphed over the input range **106** of the A/D converter **108**. Depending on the gain, the amplified signals may exceed the upper or lower limit of the input range **106** of the A/D converter. Each of the amplified output signals **104** is applied to the input of the A/D converter **108**. The A/D converter produces a group of data points **110** for each of the amplifier output signals. Each group of data points is analyzed. The group of data points that has the highest gain amplifier and no saturation points is used for determining the current used in the system.

[0011]   Figure 3 illustrates another embodiment **200** of the present invention, which shows an electricity meter using a digital microprocessor or microcontroller circuit. Also in this embodiment, multiple current paths are amplified by a different amount of gain, and then applied to an ADC, in this case located within a micro-processor chip **202**. The ADC then converts each of the amplified signals at different gains in a continuous process. The system

analyzes the different sets of samples to determine which is the most accurate to use in conjunction with the measured voltage to determine the power used.

[0012]   In the preferred embodiment illustrated in Figure 3, the current being measured (current through inputs Live IN and Live Out) is applied to a current to voltage converter 204. The voltage converter 204 outputs a voltage proportional to the current flow being measured by the electricity meter. This voltage representing the current is applied to a first amplifier 206. The first amplifier 206 multiplies the input current representing voltage 2 times (in this case using 1k resistors 208 at the input and a 2k feedback resistor 210). The output 212 of the first amplifier 206 is coupled to the microprocessor 202 to input a first amplified signal into the microprocessor. The output 212 of the first amplifier 206 is also coupled to the input of a second amplifier 214.

[0013]   In this embodiment the second amplifier 214 amplifies the input voltage representing the current an additional 4 times, resulting in an output 8 times the voltage signal from the current to voltage converter. The second amplifier uses 1k resistors 216 at the input and a 4k feedback resistor 218. The output 220 of the second amplifier 214 is coupled to the microprocessor 202 to input a second amplified signal into the microprocessor.

[0014]   The electricity meter shown in Figure 3 also inputs the voltage of the power being measured to compute the power. The input "live voltage signal" is reduced by a resistor divider to a level that the ADC can measure. For example, from 240 volts AC to 2.5v peak to peak. The divider in this embodiment has a 3 M resistor 222 over a 3K resistor 224. The point between the two resistors is connected to the microprocessor to provide a reduced

reference voltage to the microprocessor that represents the voltage of the signal being measure by the electricity meter.

[0015]   The illustrated embodiment shown in Figure 3 uses a voltage bias circuit **222** to provide a bias reference voltage to the amplifiers and voltage divider circuits described above. The current and voltage being measured by the electricity meter are analog signals that vary from a positive to negative value. The bias voltage circuit **222** lifts up the voltage applied to the amplifiers **206, 214** and the voltage divider to hold these voltages in a positive range that can be measured by the ADC inside the microprocessor **202**. The voltage bias circuit **222** uses a reference voltage output from the microprocessor. The reference voltage is multiplied by 0.5 using the divider circuit **228** composed of two 10k resistors. The divided reference voltage is applied to a unity gain amplifier **230**. The unity gain amplifier supplies the reference voltage as described above to the amplifiers **206, 214** and the voltage divider for the voltage input signal **222, 224**.

Other Embodiments

[0016]   Although the present invention has been described in detail, it should be understood that various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention as defined by the appended claims.